1. INTRODUCTION

1.1. THE STATUS OF AQUACULTURE IN MALAYSIA

Most Malaysians eat fish as part of their daily diet and the Malaysian population had a per capita consumption of 41.2 kg in 1996 (Fisheries Department 1996). Fisheries products have to be imported to meet this demand. According to the Annual Fisheries statistics, about 260,568 tones of fish valued RM 828.4 million was imported in 1996.

Due to the heavy demand of fish, there had been an increasing activity in freshwater aquaculture. For instance in 1995/1996, there was an increase of 17.84%.of fish production. Total fish production in 1996 was 21,987 tones.

In 1996, freshwater aquaculture production in Malaysia increased to 21,987 tones. In terms of value, there was an increase of 18.4% in value from RM 390.42 million in 1995 in to RM 390.42 million in 1996. For example the total production of ornamental fish increased by 12.10% from 253 million pieces in 1995 to 278 million pieces in 1996. In terms of value this increase was 13.30% (from RM 49.13 million in 1995 to RM 54.66 million in 1996) (Fisheries Department statistics, 1996).

Aquaculture has now developed into an enterprising industry. Most of the species cultured are high valued species such as the marine shrimp (Shahrom, 1996). Production of Tilapias, catfish groups and carps are also being organized in industrial scales.

Freshwater cultures involving the above groups and other species is carried out in freshwater ponds, cages, cement tanks and ex-mining pools. Brackish water culture of various fish species is also practiced

1.2. CONTRIBUTION OF FEEDING TOWARDS THE DEVELOPMENT OF A FISH INDUSTRY

There is an increasing attempt in many countries to develop practical diets for fish in which a significant proportion of the fishmeal component is substituted by a readily available feed ingredients from local industry (Hickling, 1971; Jackson and Capper, 1982; Winfree and Stickney, 1984; Gropp *et al.*, 1997), which have elements of protein, fat, ash and amino acid. Because of the importance of protein in tissue elaboration, protein metabolism (nitrogen retention) has been considered the fundamental unit of growth (Brody, 1945) and protein utilization has been the main focus of research into the nutrient requirements of tilapias (Cruz and Laudencia, 1977; Mazid *et al.*, 1979; Hanley, 1991).

High levels of dietary protein and energy are necessary requirements for the fish. Consequently, several studies have sought to substitute expensive protein source with lower cost protein source and by product materials (George, 1975; Bayne *et al.*, 1976) ,while others have investigated the protein-sparing effect of various food stuffs (Bayne *et al.*, 1976; Viola and Arieli, 1983), and the ability of tilapia to utilize carbohydrates and lipids as energy sources (El-Sayed and Garling, 1988).

The Tilapias are becoming an increasingly important group of culture fishes in Malaysia and other parts of Southeast Asia. Currently *O.niloticus* is the most popular tilapia species cultured throughout the world. Its fast growth, tolerance for environmental conditions and favorable breeding characteristics are only some of the traits which make *O.niloticus* a favorite fish for culture (Guerrero *et al.*, 1980). Nevertheless our understanding of the nutritional requirements of tilapia under practical culture conditions are lacking and studies which attempt to research the effect of diet on the growth performance in tilapia are needed. Fish growth rate is determined through the combined effects of food quantity and food quality. The quantity of food consumed is regulated through the appetite to satisfy the energy requirements of fish (Rozin and Mayer, 1961 and 1964). Limited food availability that does not allow full appetite satisfaction results in growth rates below the maximum potential.

Food quality depends on the composition of the diet, and the extent to which the components are digested and assimilated. Quality is rarely a limiting factor in the growth of carnivores since their diet is consistently of very high quality, but the quality of diets consumed by herbivores and detritivores is extremely variable.

Food quality appears to limit the growth of tilapias in natural populations, the limited data available indicate that within a given water body, tilapias select precisely the food that will maximize growth. The combined abilities for cell wall lysis and selective feeding suggest that tilapias hold considerable promise for low technology, protein efficient aquaculture (Pullin and Low- McConell, 1982).

1.3. SCOPE OF DIET ON GROWTH IN TILAPIA CULTURE

Diet formulation is a process in which the appropriate feed ingredients are selected and blended to produce a diet with the required quantities of essential nutrients (De Silva and Perera, 1995). As indicated earlier, no single ingredient can be expected to meet all the nutrient requirement of a cultured organism. By selecting various ingredients in the correct amounts, a compounded ration which is nutritionally balanced, palatable, pelletable and easy to store and use may be formulated. For example nutrient requirements of the species cultured, the feeding habits of the species, local availability, cost and nutrient composition of ingredients (Michael, 1987; De Silva and Perera, 1995).

Many factors need to be considered when formulating feeds for use in aquaculture. In aquaculture, as in any other form of husbandry, both nutrition and feed cost have to be taken into account (Hickling, 1971). Feed cost is considered to be the highest operational cost in both intensive and semi-intensive aquaculture system and therefore special consideration needs to be given to this aspect in diet formulation.

Supplying adequate nutrition for various aquaculture species involves the formulation of diet containing about 40 essential nutrients and the proper management of a multitude of factors relating to diet, quality and intake (Tacon and Cowey, 1977; Michael, 1987 and De Silva and Perera, 1995).

In essence, bioavailability of nutrients, diet acceptability, palatability, feed manufacturing, storage methods and chemical contamination can have profound effects on the quality of the diet and hence performance and production of cultured organisms (De Silva and Perera, 1995). Undoubtedly, formulation needs to be taken into consideration the nature of culture practice. In intensive culture systems the formulated feed needs to provide all the nutrition.

Nutrition has been found to influence body weight. The quality of a feed is a function of how well that meets the nutrient requirements of a fish. Not only must the feed contain the correct proportion of nutrients, but the nutrients must be able to be digested and absorbed in a form that makes them available for providing energy and substrates for growth to the fish (Hickling, 1971; Pullin and Low-McConell,1982; De Silva and Perera, 1995). The digestibility of the food is currently the primary determinant of bioavailability (De Silva and Perera, 1995).

The major problem with using digestibility of feed ingredients is that it varies with species, source of nutrient, the temperature at which it is evaluated and often between two samples of exactly the same foodstuff that are treated in different ways (e.g. different heats of drying) (Pfeffer *et al.*, 1991). These factors make it difficult to relate the data obtained by separate groups of workers, or even by one group of workers at one time with those obtained by the same group at different times (De Silva and Perera, 1995).

1.4. MAJOR COMPONENTS OF FEEDSTUFF:

Moisture (water) is an important diluent of the nutrients in foodstuffs. It is necessary to know the moisture content of raw materials and compound feeds as check on their feeding requirements, for use in calculating analytical data on a dry matter basis and also because moisture has important function in determining the form of diet.

Fats are the fatty acid esters of glycerol and are the primary means by which animals store energy. Fish are able to metabolize lipids readily, particularly when deprived of food (Michael, 1987) as for example, during the migration of Salmon. Phospholipids are components of cellular membranes. Sphingomylins are found in brain and nerve tissue compounds. Steroids are important components of, or precursors of sex and other hormones in fish and shrimp (Michael, 1987; Tacaon *et al.,* 1990; De Silva and Perera, 1995).

Proteins are large complex organic compounds which perform an essential role in the structure and functioning of fish or other animals (De Silva and Perera, 1995). Dietary protein is therefore essential for all fish. The optimum dietary level of protein is that which produces maximal growth. However protein acts as an energy source as well as a tissue builder and excessive levels of dietary protein may form an expensive way to supply energy (Michael, 1987). The optimum dietary protein level may not be the most economic to use.

Proteins are composed mostly of amino acids. There are twenty major amino acids. The amino acid composition of protein from different sources varies widely. Some proteins have none of certain amino acids. Some amino acids can be synthesised by animals; those that cannot be synthesised are called essential (essential in the diet) amino acids or EAA's (Michael, 1987; Tacon *et al.,* 1990). For fish the EAA's are arginine, histidine isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.

Amino acids contain different amounts of nitrogen; thus the protein level in feed composition is never accurate. Other compounds contribute nitrogen and are detected in the analytical test to determine protein level. The crude protein level is calculated by multiplying the nitrogen level determined in the analysis by 6.25 (Michael, 1987; Tacon *et al.*, 1990).

Protein synthesis will continue until the limiting amino acid is completely consumed, although this process is not 100% efficient (De Silva and Perera, 1995), that is some of the limiting amino acids will be used to provide energy. The amino acids will be deaminated and used for energy. The process of protein synthesis has an energy demand on top of the basal metabolic rate (Tacon *et al.*, 1990). Unless a form of non-protein energy is provided in the diet, an animal has to direct amino acids into energy liberating pathways in order to provide the energy needed for basal metabolism and growth (Michael, 1987; Tacon *et al.,* 1990; and De Silva and Perera, 1995). This will limit the scope for growth.

Fish growth involves the laying down of muscle, fat, epithelial and connective tissue. The proportion of protein or fat laid down in these tissues, is highly dependent upon the diet (Michael, 1987). In order for protein synthesis to occur, the correct ratio of essential amino acids must be provided. Essential amino acids are those amino acids that a fish is incapable of synthesizing and that therefore have to be provided in the diet (De Silva and Gunasekera, 1989; Tacon *et al*, 1990).

Carbohydrate is utilized less efficiently by fish as an energy source, but is much less expensive than other alternative sources of energy for fish diets (De Silva and Perera, 1995). There is considerable controversy about the optimal level of carbohydrate that may be included in aquatic animal feed. This level varies according to species, from less than 12% in rainbow trout (Philips *et al.*, 1994) to as high as 33% for channel catfish (Wilson, 1991). Carbohydrate has limited use as an agent providing energy and so for sparing protein in the diets of finfish (Cowey *et al.*, 1985). This is unfortunate, since carbohydrate can be a particularly cheap source of diet and energy. This is not to say that carbohydrate has no role in fish diets (De Silva and Perera, 1995). Some carbohydrates are normally regarded as indigestible.

Fiber includes substances such as cellulase (from plants),, lignin, chitin, etc. Many fish do not have the enzyme cellulase which is necessary for the digestion of cellulase, and fiber is usually regarded as unavailable as an energy source. At small levels, however, it may aid palatability. Cellulase however is produced by the gut bacteria of many fish, as is chitin's in crustacean, and herbivorous fish are able to digest fiber (Michael, 1987).

There has been a traditional reliance upon fishmeal as a protein source in diets for farmed species. Fish meal is expensive relative to other protein sources and a number of investigations have addressed the effectiveness of replacing the fish meal with some other protein source, for instance some types of grain meal (e.g. soybean meal, cottonseed meal) (Hickling, 1971; De Silva *et al*., 1991). It has generally been found that most alternative protein sources are able to replace fishmeal to some extent. A number of factors affect the proportion of fishmeal that can be replaced, and these depend upon the nature of the protein source.

As implied, within any one species, protein-energy ratios of diet are also of significant importance. Body composition is the amount of moisture, protein, carbohydrate and fat contained in a fish carcass. Optimizing body composition to yield the maximal dressing percentage (the proportion of saleable product expressed as a percentage of the whole fish), and sensory quality (taste) is important for an aquaculturist since it is directly related to profitability (Reis *et al.,* 1989; Parazo, 1990).

The majority of the gross energy of feed is contained in one of three types of molecules, namely carbohydrates, lipids and proteins. The proportion of the relative components (i.e carbohydrates, lipids or proteins) in the diet can be determined by chemical analysis (Michael, 1987). The energy contribution of each component to the total energy of the diets is then calculated by multiplying the proportion of that component in the diet by an appropriate factor known as the physiological full value (De Silva *et al.,* 1991).

Vitamins are complex organic substances, usually of comparatively small molecular size (molecular weight usually less than 1000) (Cho, *et al.,* 1985). They are distributed in feedstuffs in small quantities and form a distinct entity from other major and minor food components. Vitamins are needed for normal growth, maintenance, and reproduction of animals. The availability of vitamins may increase during processing, approximately 90% of the niacin in cereal grains is bound to polysaccharide complexes and is therefore unavailable (Lall, 1991). The absence of any vitamin from the diet was formerly regarded as leading to specific deficiency symptoms that are nonspecific (Cho *et al.*, 1985).

Mineral elements are important in many aspects of fish metabolism. They provide strength and rigidity to bones in fish. In body fluids they are involved mainly with the maintenance of osmotic equilibrium with the aquatic environment and the nervous and endocrine systems (Michael, 1987), they are components of enzymes, blood pigments and other organic compounds. They are essentially involved in the metabolic processes concerned with energy transport (Tacon *et al.*, 1990).

1.5. PROBLEMS ON STRAINS AND DIET IN TILAPIA

Fish growth rate is determined through the combined effects of good quality genetic factors (De Silva and Perera, 1995) and the environment in which the fish are kept. The dietary requirements of the important culture species and hybrids must be defined so that supplemental feed can be formulated on a sound technological basis (Michael, 1987). Because supplemental feed is a major cost item for intensive or semi intensive culture, studies on the physiology of digestion and assimilation of feeding rate and frequency components can reduce feeding cost but must be nutritionally adequate (Hickling, 1971).

Applied research on the genetics of tilapias can have rapid payoffs as the tilapia culture industry expands. It should be recognized, however that all work on genetic improvement is high-risk (*high-investment*) research and therefore the success of genetic improvement work depends on optimum nutrition given to the fish, efficient management and prevention of diseases.

Although some of the tilapias currently available have good culture characteristics, there is much room for improvement by selection of strains for fast growth, higher fecundity and late maturity. All these three traits' full potential can be expressed with a balanced diet given to the fish. However the diet has to be inexpensive because the Tilapia's status as an economic fish needs to be maintained. Furthermore there may be a necessity to formulate different feed requirement for different strains of tilapia as their growth patterns are different (Mukherjee *et al.*, 1994)

1.6. OBJECTIVES OF THE PRESENT EXPERIMENT

There are several strains of tilapia distributed in many water bodies of Malaysia. An evaluation of these strains for their productive potential has been presented earlier (Mukherjee *et al.*, 1994). Three of the above strains (*Oreochromis mossambicus*, *Oreochromis niloticus,* Philippines and *Oreochromis niloticus,* Local) were selected for this study with the following objectives:

1. To investigate the effect of two different diets on growth, conformation and carcass composition of three strains of *Oreochromis*.
2. To study the effect of strain x diet interaction on the above traits.